The unexpected results of the present invention are represented by the data of Example I, which involves the effect of the addition of zinc oxide during rubber mixing.

Rubber compounding may involve at least two mixing stages: at least one non-productive stage and at least one productive stage. Productive stages include addition of curatives such as sulfur and accelerators, while non-productive stages do not. It may be desirable to add zinc oxide during a productive mixing stage rather than during a non-productive stage, because addition of zinc oxide in the productive stage may give superior properties in the final rubber vulcanizate, such as better rebound, abrasion resistance, modulus ratio, tan delta, and tensile strength. This is observed in the present specification by comparing the properties of each pair of samples in Tables 1 and 2 of Example I: A vs B; C vs D; and E vs F. Each of these pairs represents a common rubber, but with zinc oxide added either in a productive (PR) or a non-productive (NP1) mix stage. In each case, superior properties are observed with productive mixing of zinc oxide (A, C, and E) compared to non-productive mixing (B, D, and F).

A constraint on the addition of zinc oxide is the compound viscosity (MS/1.5 100°C): zinc oxide tends to increase the compound viscosity. If the viscosity is too high the compound is less processable, and it may be necessary to add additional processing aids such as oil to maintain processability. In Example I, the viscosity is greater with productive mixing of zinc oxide (A, C, and E) as compared with non-productive mixing (B, D, and F). However, with conventional emulsion styrene-butadiene rubber (ESBR) and productive stage mixing of zinc oxide (Sample E), the viscosity is significantly higher so additional processing oil is used to keep the viscosity within a usable range. This is not the case with multi-viscoelastic response rubber (MVR, Samples A and C). Even with the additional process oil (28 phr for Sample E vs 20 phr for samples A and C), the viscosity is significantly greater for conventional ESBR in Sample E than for the MVR samples in Samples A and C. Table A shows the viscosity for the productive mix samples, and Table B shows the viscosity for the non-productive mix samples.

Table A. Zinc Oxide Added in Productive Mix Stage

Samples	A	C	E
Rubber Type	MVR	MVR	non-MVR
oil, phr	20	20	28
MS/1.5 100°C	45.5	45	53

Table B. Zinc Oxide Added in Non-Productive Mix Stage

Samples	B	D	F
Rubber Type	MVR	MVR	non-MVR
oil, phr	20	20	28
MS/1.5 100°C	34.7	34.2	37

As indicated in Table A for samples with productively mixed zinc oxide, the MVR rubber samples showed significantly lower compound viscosity than the non-MVR rubber sample, with an improvement in viscosity of 7.5 to 8 viscosity units. In Table B, for non-productively mixed zinc oxide, the MVR rubber samples showed only a slightly lower compound viscosity than the non-MVR rubber sample, with an improvement in viscosity of only 2.3 to 2.8 viscosity units.

The effect is more pronounced when considering that the non-MVR rubber (E) contained an additional 8 phr of oil. If this extra oil were not added, the viscosity of the non-MVR sample (E) would have been higher and the compound would have been less processable.

These results show that with MVR rubbers, it is possible to obtain the more desirable vulcanizate properties obtained with productive mixing of zinc oxide as compared with non-productive mixing of zinc oxide, because the viscosity of the productively mixed compound remains at a desirable level. The results are highly unexpected and surprising: as with conventional ESBR, with MVR rubber it would be expected that during productive mixing the compound viscosity would increase to an undesirable level. Unexpectedly and surprisingly with MVR rubber, however, the compound remains processable even with zinc oxide added in the productive step.

Applicants urge that these surprising and unexpected results are sufficient to overcome a prima facie showing of obviousness.

Applicants urge that for all of the foregoing reasons, the claims are fully patentable over the cited references, and respectfully request allowance of the claims.

Respectfully submitted,

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